Heavy Metals in Domestic Drinking & Effluent Waters

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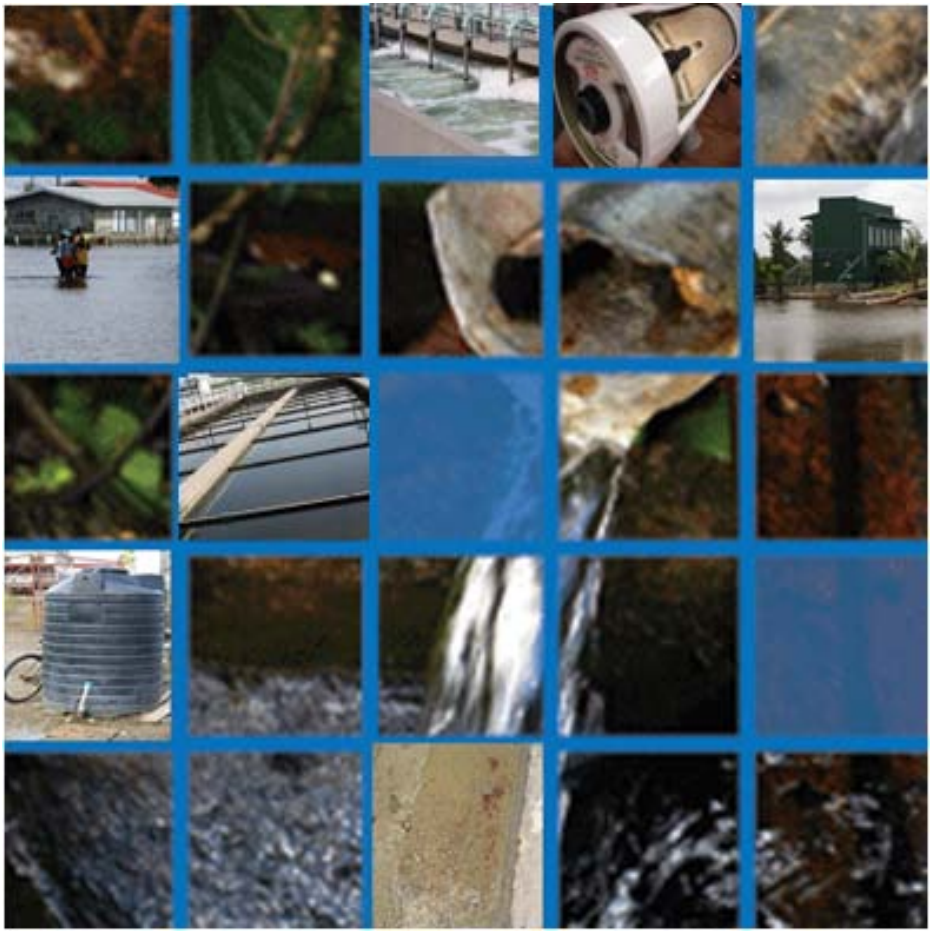
The Impending Water Crisis of Tampa Bay: Waste, Reuse & Environmental Protection
USF College of Public Health

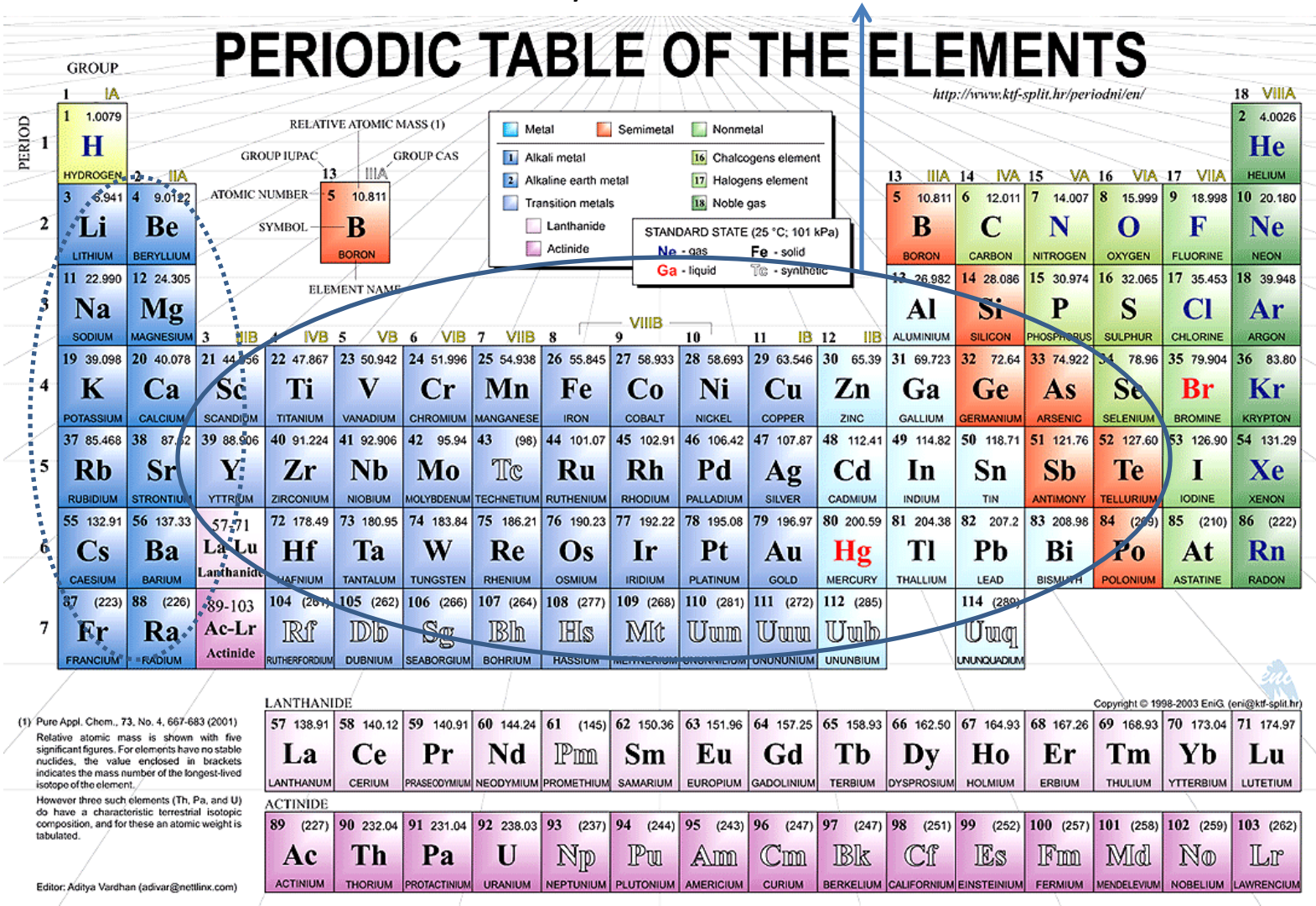


Outline

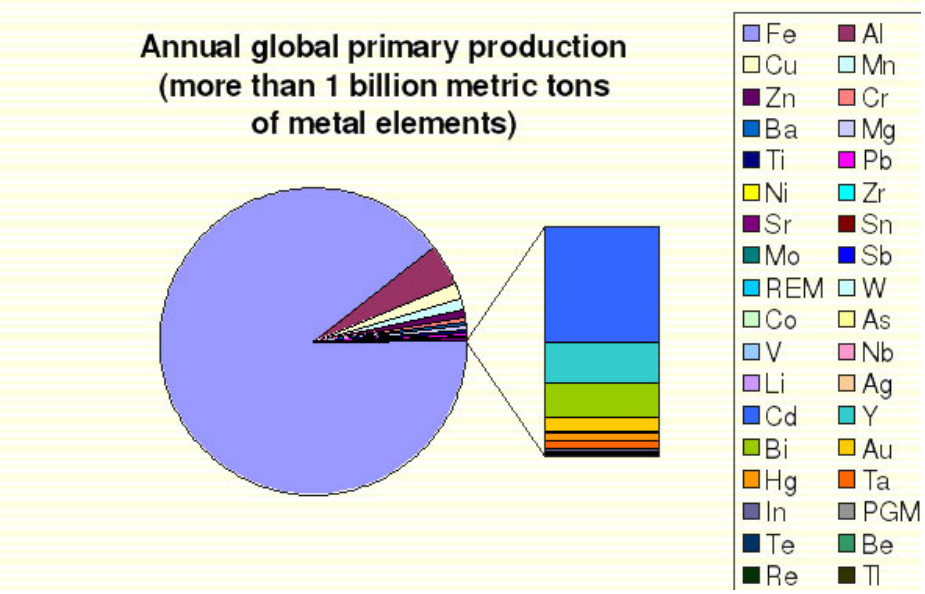
- What are heavy metals?
- Why are we concerned with them?
- What regulations apply to them?
- What are current treatment options?
- Should we be concerned with heavy metals in effluent from the Howard F. Curren Advanced wastewater treatment plant?
- Some things to consider:
  - Are you concerned with heavy metals in your tap water?
  - Are heavy metals in grey water a potential issue?
  - What about heavy metal release during Aquifer Storage & Recovery?
- Conclusions

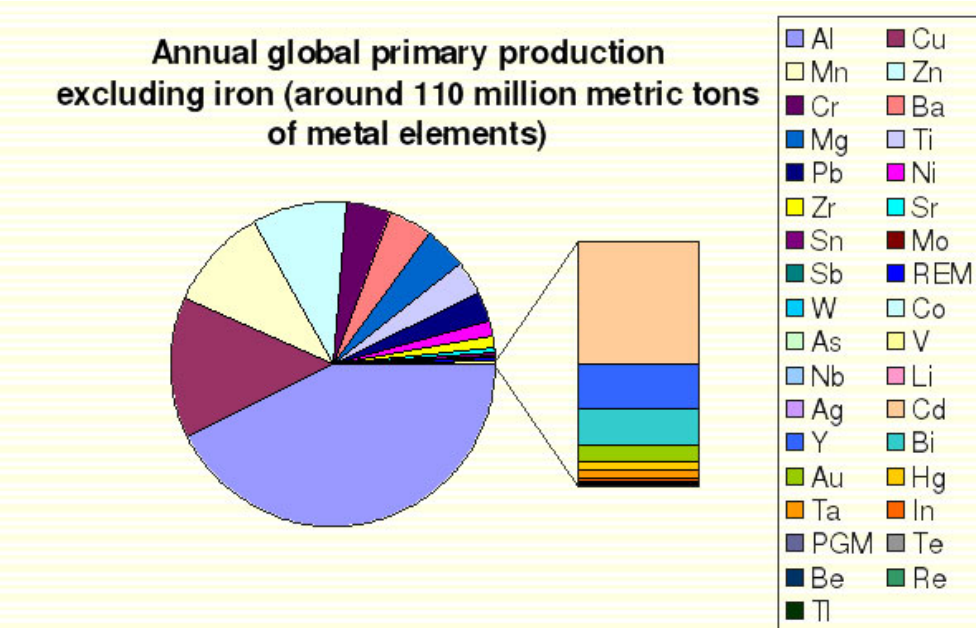
What are “heavy metals”?

No clear definition, but usually includes metals that have some toxic effect.



How much heavy metals do we produce?





2008 Data

Dr. A.M. Diederen, MSc., Metal minerals scarcity: A call for managed austerity and the elements of hope. Based on data from United States Geological Survey (USGS), ***Mineral commodity summaries 2008***

Contaminant	Potential Health Effects from Ingestion	Sources of Contaminant
Antimony	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronicsproduction wastes
Barium	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits
Beryllium	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries
Cadmium	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints
Chromium (total)	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	Short term exposure: Gastrointestinal distress	Corrosion of household plumbing systems; erosion of natural deposits
	Long term exposure: Liver or kidney damage	
	People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	
Lead	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities	Corrosion of household plumbing systems; erosion of natural deposits
	Adults: Kidney problems; high blood pressure	
Mercury (inorganic)	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands
Selenium	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories

Types of reuse applications

We reclaim water from wastewater treatment plants for various reuse applications.

- Unrestricted Urban
  - Irrigation
  - Toilet Flushing
  - Fire Protection
  - Construction
  - Landscape Impoundment
  - Street Cleaning
- Restricted Urban
  - Golf courses
- Agricultural (Food Crops)
- Agricultural (Non-food Crops)
- Unrestricted Recreational
- Restricted Recreational
- Environmental (Wetlands)
- Industrial
- Groundwater Recharge (Nonpotable Aquifer)
- Indirect Potable Reuse

various water quality criteria and regulations

http://epa.gov/nrmrl/pubs/625r04108/625r04108chap2.pdf

EPA Recommended Limits for Heavy Metals in Reclaimed Water for Irrigation

Constituent	Long-Term Use (mg/l)	Short-Term Use (mg/l)
Aluminum	5.0	20
Arsenic	0.10	2.0
Cadmium	0.01	0.05
Chromium	0.1	1.0
Cobalt	0.05	5.0
Copper	0.2	5.0
Iron	5.0	20.0
Lead	5.0	10.0
Manganese	0.2	10.0
Molybdenum	0.01	0.05
Nickel	0.2	2.0
Selenium	0.02	0.02
Vanadium	0.1	1.0
Zinc	2.0	10.0

Up to 20 years

http://epa.gov/nrmrl/pubs/625r04108/625r04108chap2.pdf

Treatment Technologies

Selected Component to be removed	Drinking Water Standard	Coagulation, Sedimentation	Lime Softening	Adsorption			Ion Exchange		Membrane Filtration	
				GAC	PAC	Activated Alumina	Anion	Cation	Reverse Osmosis	Ultrafiltration
Arsenic (+3)	0.010	G-E	F-E	F-G	P-F	F-E	G-E	P	E	P
Arsenic (+5)	0.010	G-E	F-E	F-G	P-F	F-E	G-E	P	E	F
Copper	1.3	G	G-E	F-G	P	-	P	F-G	E	-
Lead	0015	E	E	F-G	P-F	P	P	F-G	G-E	-
Mercury	0.022	F-G	F-G	F-G	P	P	P	F-G	G-E	-

Performance rating at removing selected component: E – Excellent, G – Good, F – Fair, P – Poor.

Water reuse: Issues, technologies and applications. Takashi, A. et al., (2007). Metcalf & Eddy.

Removal of heavy metals after various treatment stages in wastewater treatment

	Raw Conc. µg/L	Primary Effluent		Secondary Effluent		Tertiary Effluent		Advanced Water Treatment Effluent		Overall %R
		Conc. µg/L	%R	Conc. µg/L	%R	Conc. µg/L	%R	Conc. µg/L	%R	
Arsenic	3.2	3.1	3	2.5	19	1.5	30	3	40	92
Cadmium	0.6	0.5	17	12	0	0.1	67	0.1	0	83
Chromium	3	4	0	2	32	1	24	1	25	83
Copper	63	79	0	43	33	9	52	11	0	83
Iron	600	534	11	180	59	50	22	40	2	94
Lead	5	6	0	6	0	1	93	1	0	91
Mercury	0.3	2	33	0.1	33	1	0	0.1	0	67

Water reuse: Issues, technologies and applications. Takashi, A. et al., (2007). Metcalf & Eddy.

Are metals a concern in effluent from Howard F. Curren Advanced Wastewater Treatment plant in Tampa, Fl?

	Ni ug/l	Hg ug/l	Ag ug/l	Cu ug/l	Ni ug/l	Pb ug/l	Zn mg/l
Effluent 1/13/10	3.7	<0.04	<4.0	<8	5.0	<12.0	0.014
SWQS Permit Level	8.3		2.3	3.7		8.5	0.086
Freshwater chronic	52.0	0.77			52.00	2.5	0.120
SDWA MCL		2		1300		15	

	Tl ug/l	Al mg/l	As mg/l	Ba mg/l	Be mg/l	Ca mg/l	Co mg/l
Effluent 1/13/10	<52	<0.060	<0.012	0.011	<0.001	96.6	<0.004
SWQS permit Level	6.3	1.5	0.05		0.0001		
Freshwater chronic		0.087	0.15				
SDWA MCL	2		0.01	2.000	0.004		

	Cd mg/l	Cr mg/l	Fe mg/l	K mg/l	Mg mg/l	Mn mg/l	Mo mg/l
Effluent 1/13/10	<0.001	<0.008	0.049	16.3	27.40	0.010	0.004
SWQS permit Level	0.009	0.08					
Freshwater chronic	0.0003	0.011	1.000				
SDWA MCL	0.005	0.1					

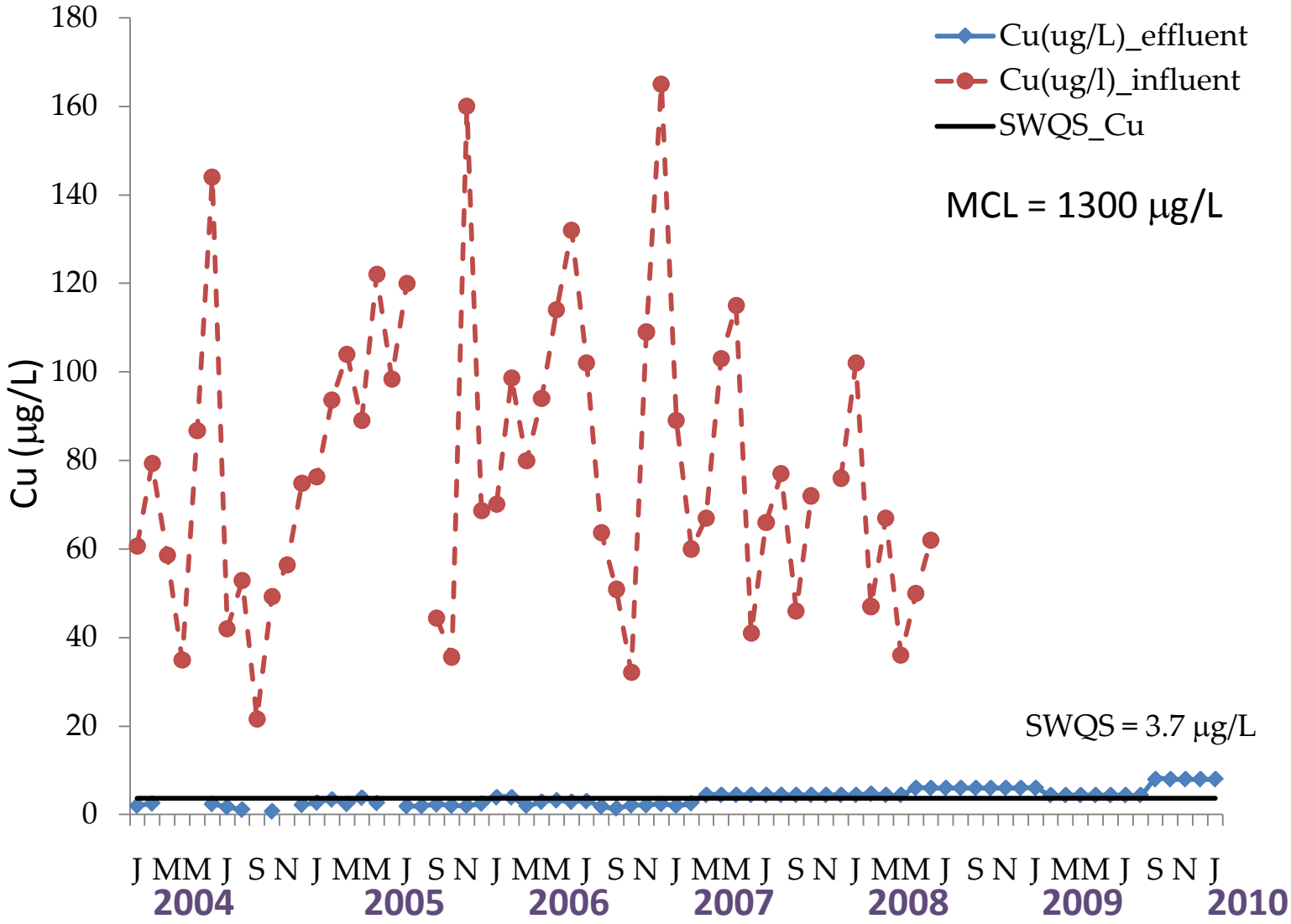
	Na mg/l	Sb mg/l	Se mg/l	Sr mg/l	V mg/l
Effluent 1/13/10	193.0	<0.024	<0.016	0.450	<0.004
SWQS permit Level		4.3	0.071		
Freshwater chronic			0.005		
SDWA MCL			0.05		

The **detection limit at the lab** for As is 12 µg/l.

Meeting the SWQS permit level

Don't know if meets SDWA

Howard F. Curren Wastewater Treat Plant: Cu data



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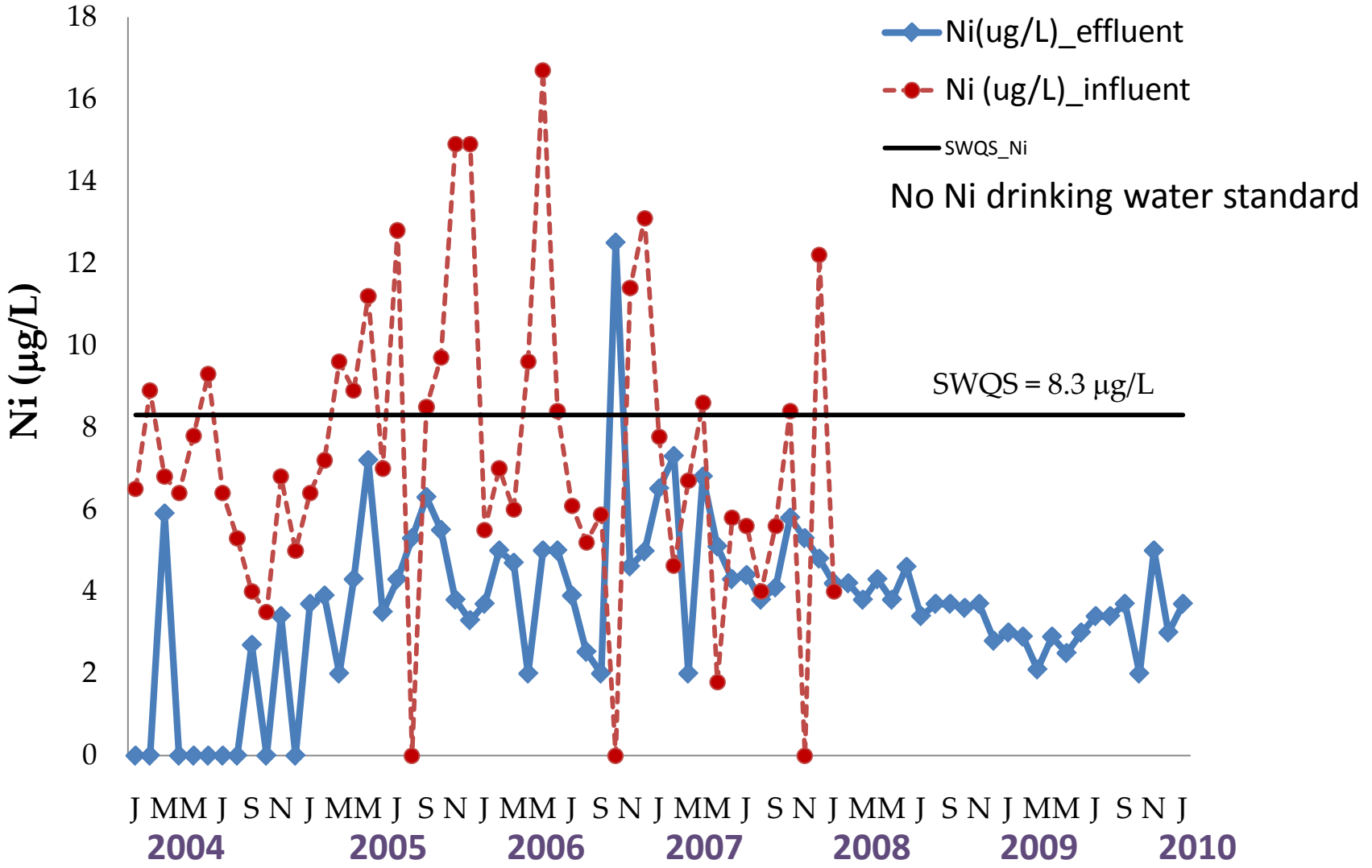
Howard F. Curren Wastewater Treat Plant: Ni data



What about water out of your tap?

WATER TREATMENT PLANT

Water meets SDWA requirements

HOUSE PLUMBING MAINS

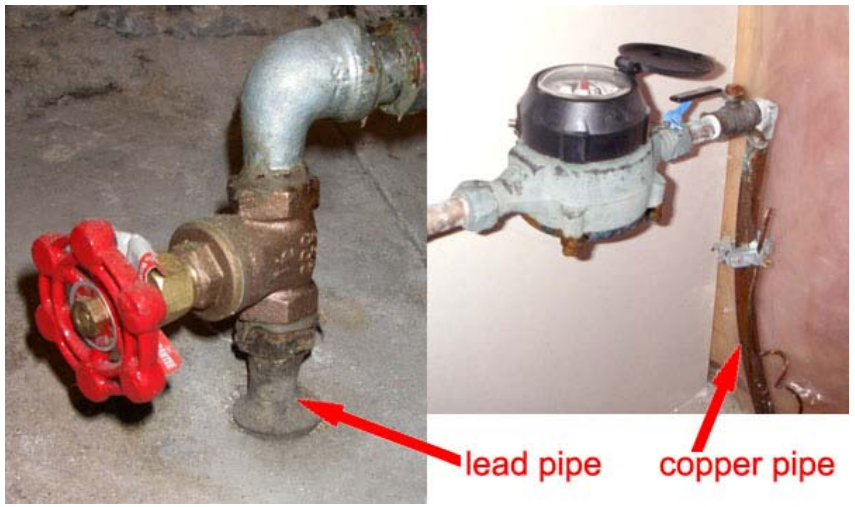


Image from: http://www.winnipeg.ca/WaterAndWaste/images/waterleadCopperPipe.jpg

YOUR TAP

Does water still meet SDWA requirements?

Are your pipes corroding and releasing heavy metals?

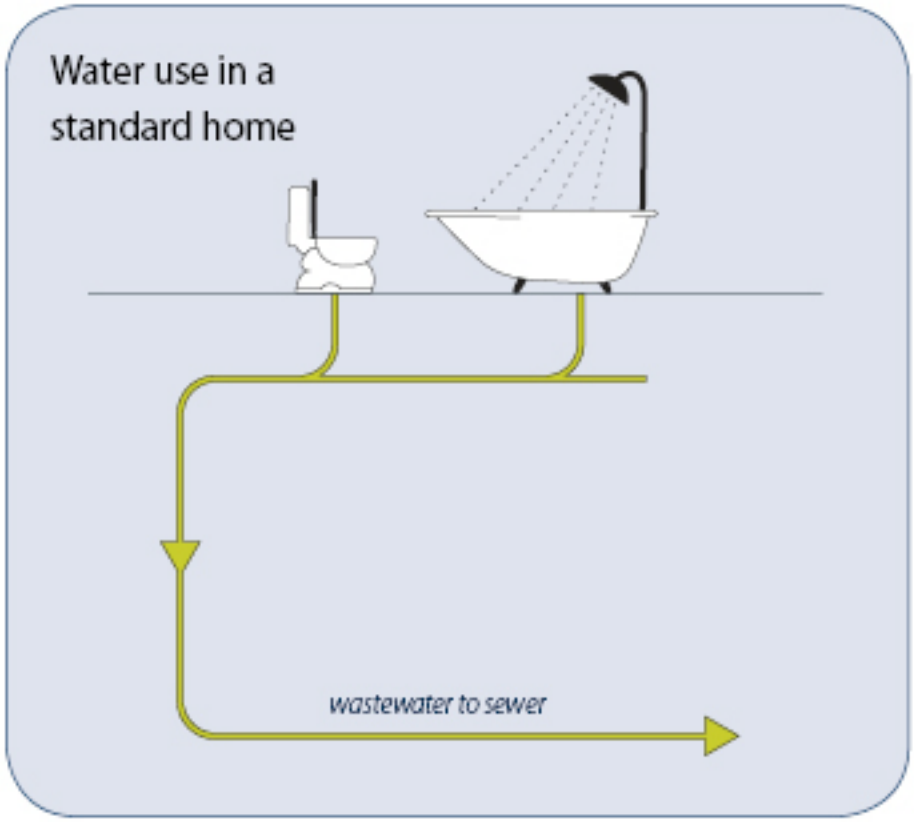
Should you flush taps with cold water in the morning?

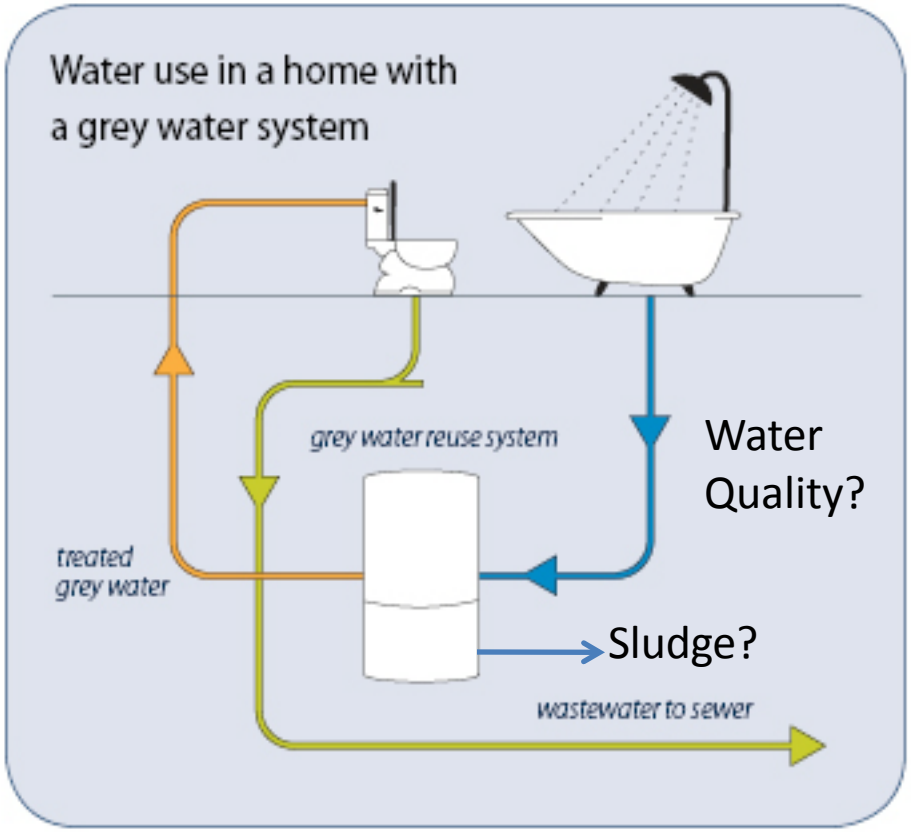
http://www.epa.gov/safewater/lead/leadfactsheet.html

Changes in water quality as a function of time & location in the distribution system

Heavy metals in grey water

Potential sources in the house: plumbing materials, cutlery, jewelry, coins, home maintenance products, arts and craft products, dental fillings.



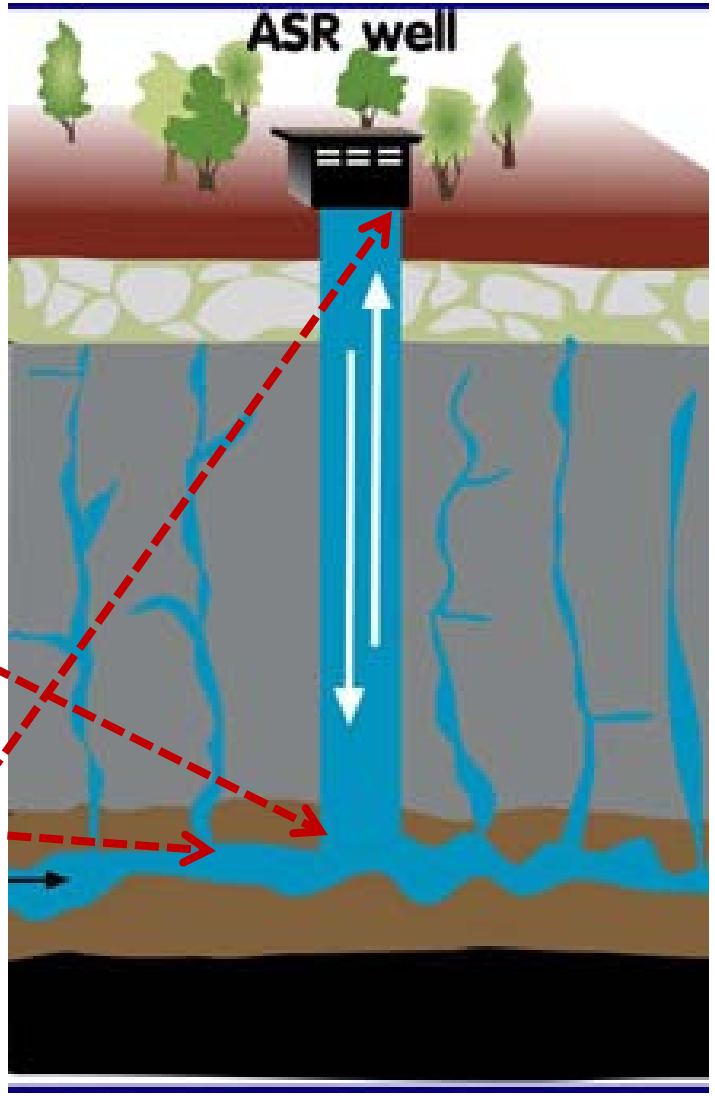


Changes in water quality as a function of household & treatment option

http://guelph.ca/uploads/ET_Group/waterworks/Grey%20water/home%20water%20use.jpg

Aquifer Storage & Recovery (ASR)

- Storage of water in an aquifer to be used later
- Proposed injection of wastewater effluent
  - Water quality of injected water different from groundwater
  - Changes in groundwater concentrations possible
    - Dissolution/precipitation reactions
      - Possible increase in heavy metal concentrations
      - Additional treatment needed to remove heavy metals once pumped



Conclusions

- Heavy metals refers more to metals (transition, alkali earth, semi metals) in the periodic table that cause some toxic effect and are regulated.
- Heavy metals are used in many products & they never degrade.
- Worldwide bans on mercury and lead use can reduce our exposure to these metals.
- Various guidelines exist for aqueous heavy metal concentrations depending on the intended use of the water.
- Concentrations of heavy metals in wastewater effluent depend on treatment employed and at the Howard F. Curren wastewater treatment plant they are usually on the order of or below drinking water standard concentrations.
- Grey water systems can potentially expose us to higher concentrations of heavy metals than traditional sewer systems.
- We may be exposed to high concentrations of heavy metals through changes in water quality in the distribution system, especially due to corrosion.
- Aquifer Storage and Recovery processes can alter groundwater concentrations of heavy metals. This will require additional treatment when we wish to use it, but for most cases the technology exists.

Thank You.

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